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ABSTRACT

Scientists and educators examined long-term national and world trends related to the web of interrelationships involved in climate, food production, population, land use, and environmental quality. Current information and projections for the next quarter century were discussed. In reviewing scientific findings, it was noted that global weather will fluctuate more in the next 25 years than it has during the last 2 decades. Discussions on how to decrease some of the 50 percent crop loss from rodents, insects, disease, waste, and spoilage were triggered by knowledge that world food demand today is the largest in history and that it will increase in future years. The fact that less developed countries will suffer most from food shortages and that famine, social unrest, and possible political chaos may not be far away was of considerable concern. In pinpointing new land for conversion to crops, it was noted that people create five times more desert than cropland, that expanding world population means urban encroachment on prime food producing land, and that atmospheric pollution by people may be modifying the climate enough to significantly alter the boundaries of existing croplands for the next 25 years. (JN)

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A QUERY INTO THE QUARTER CENTURY

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A QUERY INTO THE QUARTER CENTURY

ON THE INTERRELATIONSHIPS OF FOOD, PEOPLE, ENVIRONMENT, LAND AND CLIMATE

WORKSHOP
JANUARY 15, 16, 17, 1975

CABO SAN LUCAS
BAJA CALIFORNIA, MEXICO

OUTPUT REPORT

By
Elizabeth Wright Ingraham

WRIGHT-INGRAHAM INSTITUTE
COLORADO SPRINGS, COLORADO U.S.A.

This Project was funded by the Charles F. Kettering Foundation, Dayton, Ohio

November, 1975

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Front Cover: The diagram illustrates the interrelationships of the five components by causation. Cover illustration by Frank Miller.

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Special appreciation goes to Catherine Tobin Ingraham who worked as administrative assistant to the Support Team in Baja. She not only successfully moved everyone through a complex schedule of planes, meals and meetings, but, as well, offered intellectual challenge on many aspects of the report.

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The Workshop Idea

To feed the world population in the year 2000 and to correct present deficiencies, a fourfold increase in present food productivity must be achieved, an increase that is dependent on 25 years of favorable weather conditions, a lower worldwide birth rate, new land conversions, a global environment that includes no serious deterioration, and capital investments of large magnitude.

In the long run humans are generally interested in improving their well-being as it relates to cultural resource systems, social organization, shelter, spatial distribution and the presence of energy and minerals, biota, water and air.

Some of these elements are directly related to human populations, for example, cultural resource systems, social organization, shelter, and spatial distribution. Some are relatively well fixed in amount and distribution, or, their modification is primarily a technological problem, for example, minerals and energy-yielding compounds. The remaining factors, biota, air and water, are major elements of natural and man-modified ecological systems, including croplands.

There is a causal chain among these elements extending from the physical through the biological to the human system. The human system can, of course, affect the physical-biological systems and they in turn affect the human system in a continuous cycle.

In much the same manner, the problems of world food production, climate, population growth, land use and environmental quality are inextricably interwoven. It is impossible to discuss food production without considering climate. Food demands, both in quantity and quality, are pressured by population increase and land use. The landscape as perceived in a broad sense affects environmental quality both in terms of the natural system's ability to sustain itself and in terms of human perception. Further, some of these determinants are affected by the many sociological, economic, and political differences among people throughout the world.

The three day workshop held in Baja California could not hope to deal with the total spectrum of people and environment, how they perceive it, how it affects them, nor how they choose to handle the moral and philosophical issues. Rather, the workshop directed its query to the web of interrelationships involved in climate, food production and population with the added input of land use and environmental quality serving to sharpen the focus on the broader picture.

The 20 scientists and educators who met to examine the long-term national and world trends of these five components, represented a multidisciplinary group of recognized thinkers who keenly felt the need to better define problems.

Workshop Format

The format for tackling the subject matter included a complex literature search which resulted in the writing of a 142 page position paper by George Van Dyne, workshop leader. The paper was distributed to workshop participants before the meeting and served as a frame of reference to help identify the overall problems. In addition each participant presented a brief 3 to 5 page abstract on his viewpoints at the onset of the meeting. (See *References Used In The Workshop*).

The group studied current information and discussed projections for the next quarter century. In reviewing scientific findings they noted a high probability that global weather will fluctuate more in the next 25 years than it has during the last two decades. Discussions on how to decrease some of the 50 percent crop loss from rodents, insects, disease, waste and spoilage were triggered by the knowledge that today the world food demand is the largest in history and that it will increase in the years to come. The fact that the less developed countries will suffer the most from food shortages and that famine, social unrest and possible political chaos may not be far away, was of considerable concern to the participants, all of whom came from the affluent world.

In pinpointing new land for conversion to crops the participants were reminded that people create five times more desert than cropland, that expanding world population means urban encroachment on prime food producing land, and, that atmospheric pollution caused by people may

indeed be modifying the climate enough to significantly alter the boundaries of existing croplands in the next 25 years.

And finally, while it was agreed that optimistically the land and capital resources in a few of the developing countries might be able to cope with the growing food demands, the larger world issues involved in food production could not be addressed in the aggregate. In this context, by the year 2000 the problems in food production, storage, transportation, and distribution will make today's problems appear as child's play.

This report is being sent to foundations, private and public agencies and interested members of the scientific community so that the workshop findings may be shared with others who are concerned with the urgent problems that will confront the world in the quarter century 1975 to 2000.

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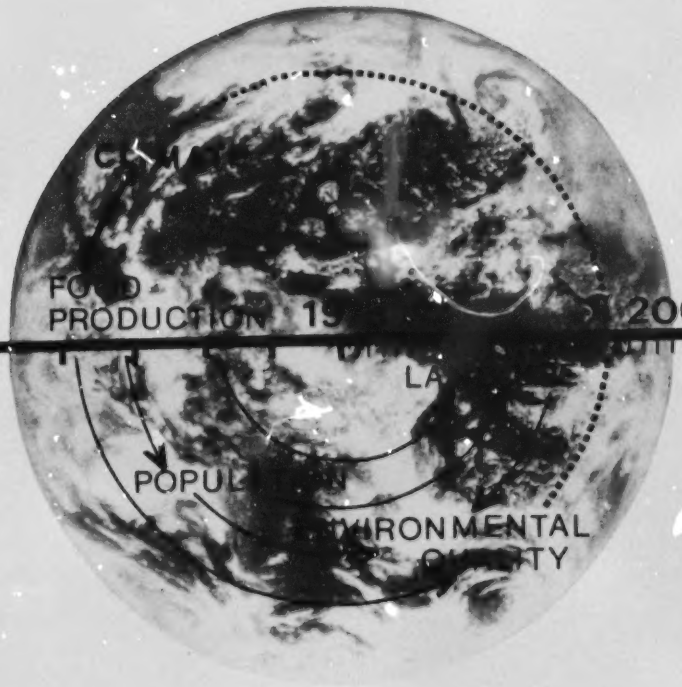

CLIMATE

THE CERTAINTY OF UNCERTAINTY

Climate: The Certainty of Uncertainty

When the Department of Commerce cautioned early in 1974 that drought that year would probably diminish American grain harvests, the United States Department of Agriculture (USDA) was skeptical. USDA responded that "better varieties and improved cultivation and fertilizer practices" had rendered grain output less susceptible to the vagaries of weather.

The year, of course, turned out to be meteorologically calamitous at an historically inopportune time. In the United States, early frosts followed an arid summer on the Great Plains that came close behind an unusually rainy spring over most of the Corn Belt. Crops were severely affected. All of this took place when cereal reserves were the smallest in 20 years and ranchers were raising livestock in record numbers.

On the world front in 1974: Spain had the driest autumn in 25 years; in the southern Pampa regions of Argentina production dropped as crops were withered by drought despite a 20 percent increase in total acreage under cultivation; and in India, sparse fall rains, though helpful for the rice harvest, hindered winter wheat production in the important Gangetic Plain (Punjab) area. At the other extreme, fall sowing was never completed in much of Europe because "abysmal" weather delayed the harvest of preceding crops and left soil conditions unfit for seeding. Torrential rains and floods in the western Ukraine severely damaged winter grains and crops which had not been harvested. In Burma, the damage to the rice crop from wide-spread rains in late summer pressured food production at a time when the country could ill afford scarcities.

In all of the above instances crop growing areas were seriously affected by climate conditions and food production suffered.

Any agricultural system that depends upon favorable weather almost certainly must fail at some point. North American growers — and many growers in other mid-latitude countries — had been misled into complacency by two decades of remarkably fortuitous conditions. In the United States there had been an extended period of favorable and relatively invariable weather during the 1950's and 1960's. Nitrogen fertilizers had become plentiful and inexpensive during the same years, while agronomic advances in plant breeding, irrigation, stocking of grasslands, etc., proceeded on a magnitude unlikely to be equalled again in the United States.

So, some scientists believe that increases or decreases in world grain production will relate less to agricultural technology than to large-scale year to year variabilities of crop weather.

Given the perspective of past changeability, the inescapable conclusion is that the climate of the coming quarter century is entering a period of wider fluctuation and will vary more than in the past 20 years. It is perilous, therefore, to project future food supplies on the basis of what happened in the 1950's and 1960's.

Cooling or Warming?

Climatologists generally agree that there will be wider fluctuation and variability of weather. They also concur by and large that after many decades of gradual warming, the world slowly is becoming slightly, but perceptibly, cooler. (See Figure 1). But whether, and how long, the phenomenon will continue are debatable matters. One unknown is the extent to which people may be changing the atmosphere by upsetting the water balance and introducing particulate matter into the air, thus interfering with insolation and radiation transfer. This enigma, the question of a cooling or warming trend, is compounded by the fact that the consequences of each are significantly different.

More specifically, the dust and smoke in the lower atmosphere filter out sunlight, thus causing the earth's surface to cool. Terrestrial warming on the other hand comes, it is thought, from the carbon dioxide build-up which is a product, principally, of the incineration of fossil fuels. CO_2 tends to remain in the atmosphere for a longer period of time than dust or smoke, and to cause a greenhouse effect, i.e. CO_2 permits incoming solar radiation to reach the earth but absorbs the reflecting or reradiating energy from the earth as longer wavelengths, thus trapping the heat near the surface.

One theory holds, then, that atmospheric accumulation of CO_2 gradually could suppress the cooling effect of pollution from particulate matter. If so, this might bring about, by the end of the century, a warming cycle that lengthens the present interglacial period. If enough carbon dioxide accumulates in the atmosphere, the planet conceivably could become so warm that the polar icecaps melt. Such melting could in-

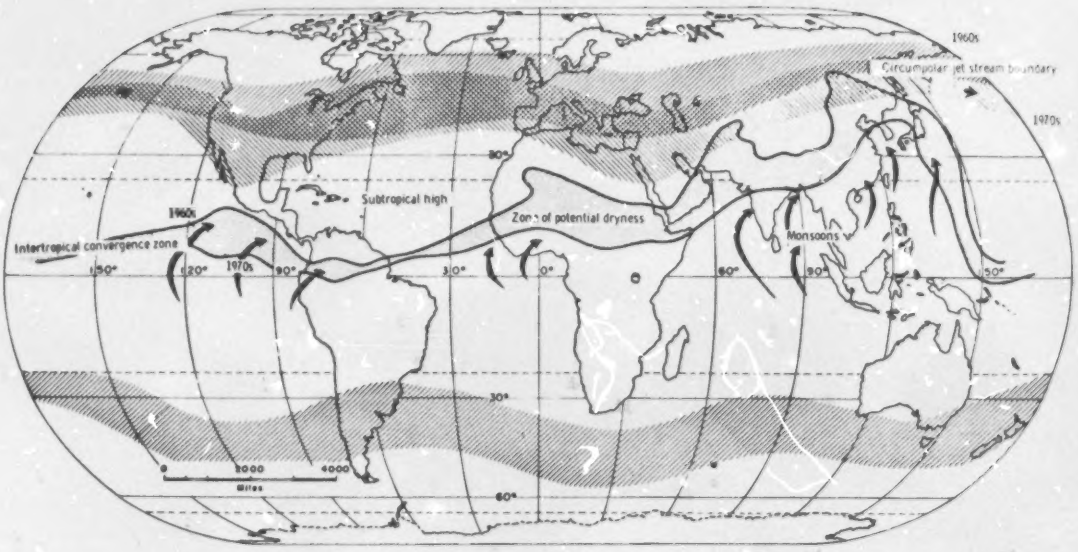

Figure 1.

A Global Cooling Trend

From Paper: *Geography & Climate of Rice*
Huke, Robert E., Dartmouth College, Hanover, N.H. 03755

crease the sea level as much as 400 feet, inundating coastal areas throughout the world. Albeit, this is estimated to require 400 to 4000 years, and fossil fuels may well be exhausted long before that occurs.

These are longer range puzzles however, and the pressing question remains, will average temperatures rise or fall from year to year during the remainder of the 20th century? No one knows; only that they will fluctuate. The irregularity in cooling and warming of the interglacial period is not cyclical enough to allow predictability.

Temperature differences are the driving force behind the location of the great wind systems. These systems, the Northern Hemisphere jet stream, the summer subtropic high pressure belt, and the intertropical front have shifted markedly toward the equator. The salient factor here is that temperatures need not vary dramatically in order to drastically affect farming and grazing. For example, a 1°C warming or cooling change would shift the boundary between the earth's *main* grain belts.

A continuation of the cooling trend actually might benefit crops in the middle latitudes — at least to a point. However, should annual average temperatures level out over the next 25 years to only 1°C less than at present, growing seasons would be shortened worldwide. That would preclude cultivation in the northernmost third of the Canadian wheat area as shown in the map (see Figure 2) and 80 percent of that in Siberia, resulting in estimated wheat production losses in those two areas alone totalling 45 million tons a year or 15 percent of present world totals.

The significance of this may be viewed in light of a reality that is new to our global food balance. The difference between the productivity of wheat and other grains in a poor weather year and a year that is favorable amounts to approximately one-tenth of annual world consumption — that is, 10 percent more or less than the total immediate

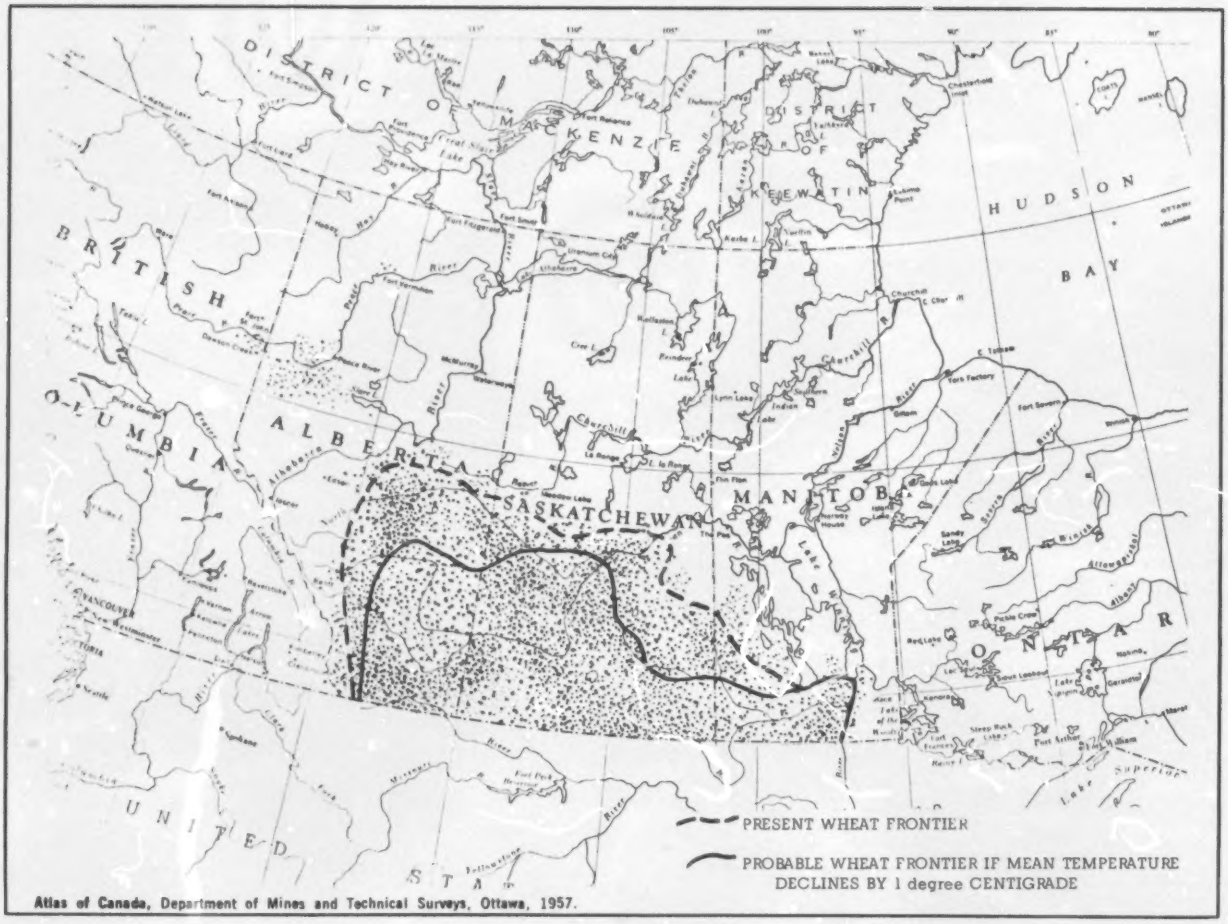

Figure 2.

Wheat and Climate

From R. Huke, Query Into the Quarter Century Workshop

requirement. Recent studies involving the effects of climate on corn and soybeans state that if weather should become as variable in the next 25 years as it was in the United States' corn and soybean belt from 1890 to 1955, the average yields would be reduced about three percent. After a year of climatic misfortunes there could be essentially no surplus at all. This means to a large degree that grain reserves will be "good weather reserves," and that reserve levels will continue to be highly susceptible to large scale meteorological anomalies over major grain producing regions.

Satellite Monitoring

Because the balance is so fragile, it becomes increasingly important to develop a global early-warning system to monitor the progress of crops in the field — and to envision the agricultural consequences of drought, floods and other natural catastrophies. The technology for such a system may be at hand.

Earth Resources Technology Satellites (ERTS), sweep around the globe and over, for instance, the Great Plains every nine days. They scan with spectrometers the distinctive light reflected by wheat and other plants. Because these multi-spectral images change significantly as the grain grows, yellowing with maturity, it is possible to continuously inventory the wheat crop of a region or of the globe. By integrating this knowledge during the season with regularly updated weather records, one can estimate the size of the approaching harvest.

This project called LACIE (Large Area Crop Inventory Experiment) is promising but still experimental. Even if it works well, there are obstacles to be overcome before the techniques can be used extensively on other crops. Some of these barriers — not uncommon to almost all aspects of the food crisis — are political. For example, suspicions linger in certain countries that the satellites might be diverted to military surveillance. Still other obstacles have to do with a paucity of basic facts and various interferences with the scanning satellites, e.g. cloud cover.

Prerequisite to the ERTS program was a regression model fabricated by the National Oceanic and Atmospheric Administration. NOAA was able to derive statistical correlations and regression equations by comparing long-term meteorological records for the Great Plains and the region's equally reliable wheat-yield history, which in some instances goes back nearly a century.

On other levels, atmospheric researchers are studying the relationship between sun spots and climate changes.

Data Needs

On a global level, where climate records and field data for most of the other food-producing areas of the world are known, the comparable climate-crop yield linkages for areas other than North America, Europe, the Soviet Union and Japan, range from good to uneven to non-existent, as indicated in *Table A*. To improve the accuracy of current climatic statistics it has been suggested that weather records over the longest time period available, prior to the decade of the 1940's, be used to produce better estimates of future variability of large scale crop-weather events.

More specifically, data are needed for the development of climate-crop yield interrelationships for rice in tropical monsoon climates, rice in non-monsoon climates, cereal grains outside of North America and for crops other than cereal and rice.

TABLE A

Food-producing regions of the world, proportion of world grain yield, and the status of data on interrelationships between climate and grain production.

	1974/1975 % of World Cereal Tonnage	Climate and Crop Yield Data
EASTERN EUROPE and U.S.S.R.	24	Climate data excellent; yield data good
NORTH AMERICA	21	Climate and yield data excellent for cereal grains; Little data on rice, sugar, potatoes, pulses (beans)
WESTERN EUROPE	12	Good climate and yield data. Well correlated.
MAINLAND CHINA	12	Approximately 50 percent rice. Information generally not available.
SOUTH ASIA	10	Good climatic data. Yield data good for India, but otherwise uneven. 55 percent tonnage in rice.
AFRICA	7	Little known.
LATIN AMERICA	6	Argentina has begun modelling on climate and wheat. Brazil developing information on corn and soybeans. Data scant from Mexico, a major grain grower.
SOUTHEAST ASIA and EAST ASIA	5	Average climate and yield data. 80 percent of tonnage in rice.
OCEANIA	1.5	Australia starting to model climate-wheat interrelationships. Although Oceania produces a small fraction of global tonnage, it grows 10 to 20 percent of total exportable grain.
JAPAN and PHILIPPINES	1	Excellent climate and yield data. Rice is grain mainstay.
OTHER	0.5	
	Total 100	

Source: Economic Research Service, USDA, World Agricultural Situation, December 1974

As the query into the quarter century continues: • Where and when will unfavorable weather contribute to crop failure and famine? • With what certainty can it be predicted? • How can people best respond to such knowledge in the planting and harvesting of crops, in planning for labor intensive vs. energy intensive production, in the conversion of land, and in the applications of agricultural technology?

The questions serve to emphasize the interrelatedness of climate and food production. It is recognized that a coordinated world-wide watch on crop production and grazing lands and their interactions with weather is now critical.

William Gaster, Georg Borgstrom

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FOOD PRODUCTION

Food Production

In recognizing that the variability of weather is a major factor in food production, the next query is "what happens if a low grain yield in the United States coincides with a U.S.S.R. shortfall and poor monsoon conditions in Asia"? Indeed, the possibility exists as the other ambient forces affecting crop yields are considered.

In terms of direct losses: rodents, birds, insects, and pests eliminate as much as 40 percent of the harvest between the field and table. The incidence of weeds and disease also take their toll. Still other losses from spoilage and waste can be directly attributed to poor collection, production and marketing methods, inadequate storage and long distance transport. Many of these losses are natural and to be expected in any biological system; however, the sum total of all reductions account for large annual losses. Only one-half of the rice crop is available as food. Between 30 percent and 50 percent of the marine foods are lost between harvesting and consumption. It has been suggested that a 50 percent potential increase in crop yield could be realized by minimizing these losses through a more efficient harvest and improved technology, particularly storage facilities.

The Green Revolution

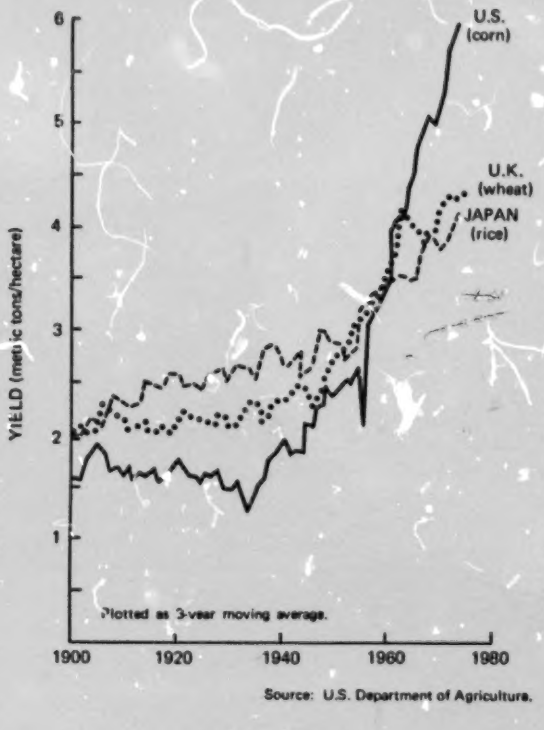
On the plus side of food production, since the beginning of the Green Revolution in the late 1940's, modern technology has cut through a long history of labor intensive agricultural practices by introducing improved machinery, better seed, improved fertilizer usage, new methods for food production, better management, and insecticides and herbicides to increase yields of grains. Biologically, the new seeds were more genetically uniform. The insecticides and pesticides effectively fought disease and crop predators. Long term loans for land shaping and irrigation, short term credit for the purchase of fertilizer, seed and pesticides, action in the control of endemic pests, fair shares in the community post-harvest facilities, and, fair prices for surplus production that went with the technology, were gains that brought better nutrition, new products, and broader food choices. Close planting, luxuriant foliage and multiple cropping were a few practices introduced to improve crops. In the last quarter century yields increased anywhere from 50 to 100 percent in irrigated areas. Such increases could not have been made without the combined efforts of science and technology. (See Figure 3)

On the negative side, however, the new technology was interfering with cultural practices of long standing, creating new social pressures and concomitantly upsetting the natural processes of biological systems. In Malaya, for example, old rice strains produced one crop per year. Fish grew and reproduced in the rice paddies between successive cultivation. New rice strains which produced more than one crop per year left the people without intervals between their crops, and hence their important protein supplement, fish, disappeared. Another example of the intrusive nature of technical advance happened outside of the city of Madras in India, where new corn strains, introduced to give villagers more food, left people without the accustomed second crop, i.e. building materials for their homes from the sturdy stalks of the old corn variety. Indeed, the new technology and seed strains associated with the Green Revolution and its dramatic yield increases during the last two decades may prove to be a mixed blessing.

Today the effectiveness of improved technology on crop yields varies greatly. The crop yield technology curve is flattening out for North America, Western Europe and Japan which means that technology cannot be relied upon to significantly reduce crop losses or increase production. Some improvements in yields aided by technology are still possible in the U.S.S.R., Eastern Europe and Oceania, and major increases because of technology can be expected for all other food-producing areas, including Africa, South Asia, Southeast Asia and Latin America. A doubling of yield in these countries may be possible in the next 25 years.

The levelling out of agricultural technology will not, however, decrease the overall size of the demand for high-yielding varieties of wheat and rice and the accompanying technologies.

In many places the fires of urban/rural conflicts are being fanned as agriculture, the top user of water in both developed and less developed countries, vies with its strongest competitor, the city, for more water in order to use fertilizer effectively. While it is true that a few miracle grains produce more profusely when either rainfall or irrigated water is scant, the requirements of 350 to 400 gallons per day per acre to raise vegetables in the field, and the 3500 to 4200 gallons per day per acre to raise food for consumption by animals that eventually reach the consumer in the form of meat and poultry, are still cause for substantial urban/rural conflict.



Source: U.S. Department of Agriculture.

Figure 3.

Selected Cereal Yields, 1900-1973

In terms of natural biological processes, breakdowns occur. In the U.S., the epidemic of Southern Corn Blight in 1970, which destroyed 20 percent of the U.S. crop, was blamed in large part on the vulnerability of the high-yielding seed strains and the accompanying technology which made the crops more susceptible to disease.

In short, the lesson of the Green Revolution is that an increase in net productivity increases the vulnerability of a system. To what degree the efficiency of large scale monocultures will decrease when technology limitations, pest damage, climate change, etc., combine with energy input limitations, is yet another question.

Grains and Meat

Looking at a few statistics, crops of major world concern include cereal grains which comprise 38 percent of the world's diet[1] and marine products which comprise 10 percent. Wheat, rice, maize (corn), soybeans, sugar, potatoes, and pulses (beans), are found on the historic grassland soils of Asia, North America, South America, Australia and Eastern Europe — the breadbaskets of the world. If increases in grain harvest in these areas employ multiple cropping techniques, they must still, of course, fulfill technological requirements.

1—USDA 1970 report states that cereal grains represent 53 percent of the caloric intake; other sources quote a figure as high as 75%.

Throughout vast areas of the world rice provides 75 percent of the total caloric intake and almost 65 percent of the protein intake. The central area for rice production is the monsoonal rainfall zone extending from Eastern India through Burma, Thailand, Laos, North Vietnam and into South China. In these areas little change in productive capacity is foreseen in the next 25 years, and no climate modification is needed. In the outer limits of rice production, i.e. those areas outside the core area, the output will be a function of energy expenditures from fossil fuels. Consequently, no production problems other than those associated with rising fuel costs are projected. As a result, agricultural experts optimistically feel that, given energy and favorable climate, it will be possible to increase world rice production by 125 percent from new techniques applied in the outer limits of the rice producing regions. The recent sharp rise in energy costs, however, may significantly alter this prediction.

A shorter food chain would provide more direct grain for human food and decrease the grain fed to animals. The desirability of various animals in food production is their high protein content compared to wheat and corn. Fish, however, not beef cattle, are more efficient producers of protein, although fish still don't exceed the 38 to 40 percent protein found in soybeans. Fish are also the best converters to high protein food, because they are small, easily handled, and adaptable to intensive production techniques. Predictions for the year 2000 indicate that farm raised fish products may comprise 15 to 20 percent of the U.S. and world's animal protein.

Food Distribution Inequities

Modern fishery fleets today belong chiefly to Japan, the U.S.S.R., and Europe. What was once considered the "last continent" of food to feed the hungry people of the world, is now being consumed by the affluent people of the world. The developed countries consume three-fourths of the world's catches of food fish. The U.S. is the largest buyer of fish and fish products, spending approximately 1.5 billion dollars per year.

In terms of producers, one half of the world's agriculturalists are subsistence farmers who are able to produce only two thirds of their own needs. Most global scarcity of food happens on the tables of the poor. The FAO standard units of 2350 calories/day/person or 857,750 calories/year for one adult, plus 2.5 liters of water per day per adult, are seldom met. Serious protein deficiencies are found throughout the world. The average banquet in India is 50 grams of protein per day per person, low compared to the 65 grams per day required by the average American male, and much lower than the 97 grams per day actually consumed by the average American.

Effective food consumption in developed countries is five to ten times greater than less de-

veloped countries (because of higher consumption and meat usage). Concerning the increase in food demand, 20 percent can be attributed to growing affluence rather than to population growth. Two-thirds of the world's food supplies are consumed by the already developed countries.

North America, Europe, the U.S.S.R. and Japan are the world's protein capitals. The world's largest buyer of beef is the United States. The U.S. is the world's largest producer and exporter of cereal crops. Europe buys more plant protein for feed (grain, oilseed and oilseed cakes) than Africa and India each consume as human food. In 1973, the U.S.S.R. purchased the largest single delivery of food and feed in world history.

Most of the less developed countries spend over 40 percent of their income on food. (63% in Ghana for example). In the U.S. though, only 22 percent of the family's annual income is spent on food. Significantly, more than 80 percent of the world food trade is between developed countries. Not until the recent development of energy resources in some of the less developed countries, has a growth in trading power been present to counter this imbalance. Despite this, there are major problems which complicate the transfer and distribution of food in the third and fourth world countries, i.e. widely dispersed populations, inadequate ports, often no land transport system and factional political disputes. As energy and food prices continue to rise and if food stocks decline over the next 25 years, adequate food as well as the supplements derived from imports may be out of reach for many less developed countries.

The attendant strain and growing disruption in food systems is affecting developed countries as well. Plans for controls such as beef rationing or taxation to bring demand into line with supply are unpopular and often impractical to implement. For example, little was done to discourage range overstocking in the U.S. in 1973 and 1974 and many already beleaguered ranchers, caught in a nationwide economic pinch, suffered heavy losses.

In the next 25 years, the doubling of world food production by added acreage or higher yield will require investments of such magnitude that no one country will be able to afford to pay the price and it remains to be seen if even a consortium of countries could afford the price. The added possibility that food-producing countries may refuse to export food except for profit compounds the problem.

Some Possible Directions

Possible alternatives for augmenting food production include the efforts of scientists and engineers to study the feasibility and practicality of land-ocean-power complexes and aquatic fertilization. One area open for application of conservation involves the production of animal food. Plant to animal mass conversion rates for beef are roughly 6.5 to 8:1 (feedlot) and for pork about 4 to 5:1. However, the ratio for farm-raised fish is seldom higher than 2:1. thus, the raising of fish (tilapia, carp, catfish, etc.) in Asia, Africa and the U.S. has produced yields of 2200 kilograms of fish/hectare, and higher production levels are attainable through controlled environments.

In livestock production, while it still takes one cow to produce one calf per year, experimentation with multiple birth systems and genetic improvements are continuing.

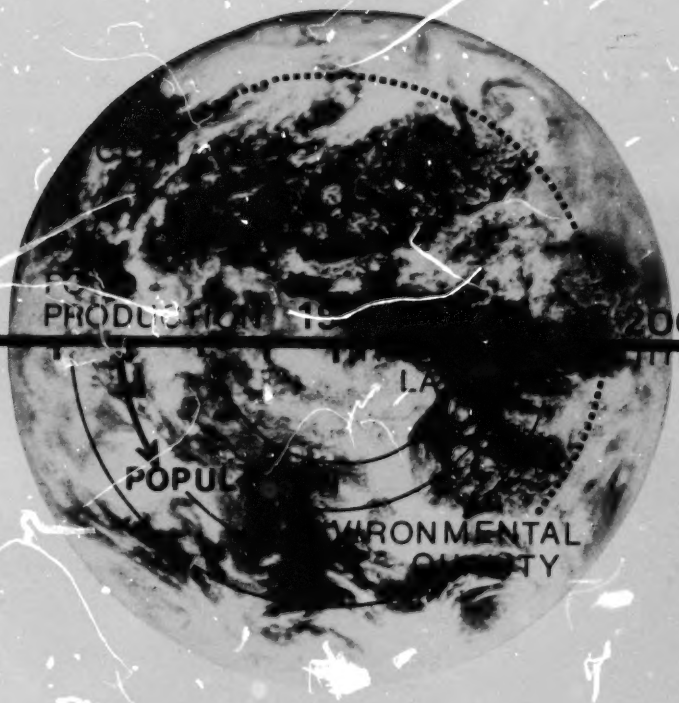
Scientists have suggested that increased crop yields could benefit from the increased use of inorganic fertilizers in certain regions; for example, West Africa. Increased efforts in plant breeding, however, and the use of future innovations in seeds, particularly in areas where yields per unit area remain "abysmal," are likely to be more strongly related to the number of introductions than to the scale of the individual operations.

The work of agricultural scientists in developing a variety of food plants with increased disease resistance should go hand in hand with the work of social scientists who could adapt innovations to societies' tastes and customs.

Speculations concerning grain reserve potential remain uncertain. Surpluses are almost nonexistent or virtually unattainable in most regions of the world. Surpluses that exist are now roughly equivalent to the difference between world-wide production in a favorable weather year and an unfavorable weather year. As the world confronts the concept of grain reserves for the future, there will be a need to find out the "optimal" configuration of a world food reserve given the variabilities of weather, loss from other factors and demands of increasing population, i.e. size, locations, distribution system, sensing decision, etc.

Political Decisions

The convening of the United Nations conference in Rome in November, 1974, was one major attempt to bring the growing food shortages into view. It was emphasized by many countries represented at the conference that decisions to increase food production through improving traditional systems, or utilizing non-conventional agricultural technologies as supplements and/or replacements for marginal large scale systems will lie largely with each nation's social, political, and economic aspirations. While much will depend on how traditional attitudes of minimization of risk rather than maximization of output are seen in terms of increased production, decisions will almost certainly demand an understanding of the interrelationships of food production with population, land use, and environmental quality on a global basis.



POPULATION

MORE FOR LESS OR LESS FOR MORE?

Food Production and Population

It seems certain that food production in the next 25 years will not be able to keep pace with the unchecked global population growth that is expected to equal the total population that occurred in the previous 40,000 years. To feed the world population in the year 2000 and to correct present deficiencies, it will require a fourfold increase in present food production. These are the foregone conclusions challenging many scientists and scholars in the world today.

Such conclusions are based on data which shows that the world food demand today is expanding more rapidly than at any time in history and that it will continue to expand as population pressures increase. One-fifth of this demand results from more food intake per person, i.e. better diets, wider food choices, increased food supplies through improved transport systems and better storage. The other four-fifths of the demand, however, results from the increase in numbers of humans on the face of the earth. At this time, one-half of the world's four billion people are inadequately fed and two-thirds of these people are critically short of most of life's necessities. And, millions of people in certain Asian cities face water shortages of serious magnitude.

Less for the Hungry

The added fact that one third of the population, most of whom are found in the developed countries, consume two-thirds of the world's primary food production on land and in the seas, raises serious questions of inequity; problems of distribution and transfer of food are a major issue. Unfortunately, the highest rates of population growth are found in the less developed countries where per capita consumption of food is the lowest and the agricultural productivity of the land is the least able to provide adequate sustenance. It is interesting to note that in the United States the highest relative population increase took place during the rise of industrial power from 1870 to 1920. The comparison, while irrelevant to specific land productivity, may serve to emphasize that a balance between exponential population growth is tied to some kind of economic development and expansion. The impact of exponential growth on food consumption in the next 25 years, however, may not be able to balance itself in such a manner. A scenario might read as follows:

> **Since achieving independence in 1950, India has added more than 200 million persons (an entire United States) and will add another 250 million by the year 1985. It will double its current population of 575 million by the year 2000 if current rates continue unchanged. India will need a twofold increase in food to feed this projected population. Because India cannot possibly harvest enough food to feed itself, it creates a dependency on already slim or non-existent world food surpluses which in turn are subject to the providence of good weather in the future. Hence, India will suffer famine because there is insufficient food. This will cause social unrest, introduce political chaos and possibly provoke wars of redistribution on a larger front. In any one of these instances, food policy could easily become a weapon thus complicating an already explosive and intolerable situation.**

The scenario could be repeated in many places as the year 2000 approaches. On the other hand, in certain areas, where increased yields are possible, crop production may be stimulated by population growth, e.g. in China where rice is the main diet.

Regional Approaches

Some scientists have suggested that it may be necessary to encourage the maintenance of regional economies as the increase in population throws more persons into the labor force. Village centers could possibly establish margins of safety by building food reserves which would more sharply represent local needs. It is clear, however, that any ideas of converting an energy intensive agriculture to a labor intensive agriculture must find social acceptability as countries struggle to be accepted in the world of nations.

The world trend in the next 25 years is projected to be moving toward a "steady state" in which a more balanced population, with a lower death rate, a declining birth rate, a longer life span, and better control of its resources, can begin to feed itself. It will take 50 years, however, to speak with assurance about how rapidly death and birth rates can be brought into balance.

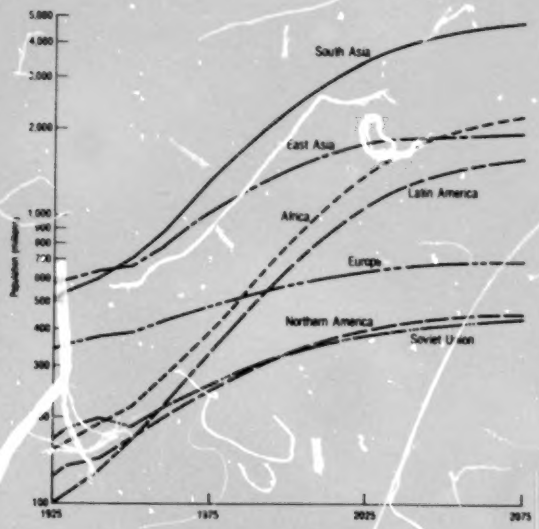
Fourfold Increase

The real worry about a world with too many automobiles and too little food is countered by a "guarded optimism" that allows for the possibility of a fourfold increase in food production if there are no major wars or natural disasters, if the climate is relatively favorable and if agricultural production is given top priority. In the final analysis, policy decisions will be influenced by how much "we," the developed countries, care if "they," the less developed countries, starve.

Population

Before 1950 the world's population was growing at less than one percent per year. Today, population growth has accelerated to an average of 1.9 to 2.2 percent per year. The world population increases by 80 million persons per year thus doubling in number in a little less than every 35 years. At this rate a world population of 6.4 billion can be expected by the year 2000 (See Figure 4). The less developed countries are multiplying at three times the rate of developed countries (0.8 to 0.9 percent per year) with approximately 2.4 to 2.7 percent increase per year. Mexico with a current population of 60 million is adding two million persons per year and Brazil with a population of about 100 million is adding three million persons per year; and, Asia, adds the equivalent of a new Japanese population every second year. We are living in a world

Population of Major Regions of the World, 1925-2075[1]



[1]According to the UN medium variant of long range projections (charted on a logarithmic scale)

Source: UN Population Commission, *Preliminary Version of Concise Report on the World Population Situation*, E/CN.9/1115/CRP.1 (14 February 1974), Figure 2, p. 50.

Figure 4.

Population of Major Regions of the World, 1925-2075

which in the last 10 years added more people than the present population of Europe. The highest population growth rates are in Central America (in excess of 3 percent per year) in Southeast Asia (1.8 to 3.5 percent per year).

During the last half century, 1920 to 1970, the average expectation of life at birth has risen perceptibly. In the United States, as population moved from 112 to 212 million, the average life expectancy rose from 55 to 71 years. One child in fifty in the United States dies before its first birthday. In China, where the life expectancy is now 57 years, and where population has risen from 500 million to almost 1 billion, one child in twenty dies before its first birthday. In Africa, where life expectancy is 45 years, one child in seven dies before its first birthday.

Not Enough Jobs

Increases in life expectancy require both social and economic accommodations, such as health care for the aged and expanded employment opportunities. For instance, one-half of the population in the less developed countries is now under 18 years of age. This poses a tremendous burden in the near future in the shape of a disproportionately large sector in the reproductive age bracket. At the same time, the structure of added population also represents an increase in the work force. In the next fifteen years in India, there will be 2250 persons between the ages of 15 and 65 for every 1000 job vacancies. In Pakistan, there will be 2850, in Mexico and Bangladesh, 3000 persons for every 1000 vacancies. This means that in Mexico, three young people will enter the labor force for every job available. Rates of unemployment and underemployment are likely to increase unless there is rapid economic and social development.

UNESCO reported that illiteracy in 1970 had increased because of the inability of poorer countries to provide schooling for the increased numbers. While the world adult illiteracy dropped from two-thirds in 1920 to one-third in 1970, the total number of illiterate people in the world actually has increased because of population growth. Such statistics are reflected continually in worldwide communication barriers.

Overcrowded Cities

Further, population is concentrating in the urban areas. Forty percent of the people live in urban areas. Within the next ten years, 600 million persons will crowd into cities; two-thirds of these will be citizens of less developed countries.

In developed countries the urban population varies from just under 50 percent to 80 percent of the total population. In less developed countries urban population ranges from 0 percent in

Africa to 100 percent in Singapore. Despite the flow of 400 million persons worldwide from rural to urban areas, rural regions will still increase by 400 million. Cities can expect a fourfold increase in the next 25 years.

Migration patterns often affect populations as they introduce social and cultural change. From 1820 to 1920, 30 million European immigrants entered the U.S. In Postwar Europe from 1945 to 1955: 13 million Germans were transferred, 4.3 million persons from Poland and three million Middle Europeans fled to other countries. Of these more than 20 million persons, five to six million went to India. Today, Brazil and Australia encourage immigration for specific types of work activities.

Livestock Impacts

A factor often forgotten is the presence of livestock. In the next ten years 5,000 million livestock in the world will be added. In India, 600 million will increase to 1.4 billion livestock, competing with people for the same cereal stocks. Human population plus livestock and poultry measured in protein intake, will amount to 15 billion in ten years. (See Figure 5). All of these figures assume that people will permit livestock increases of this magnitude. None of these figures include the food intake of pets.

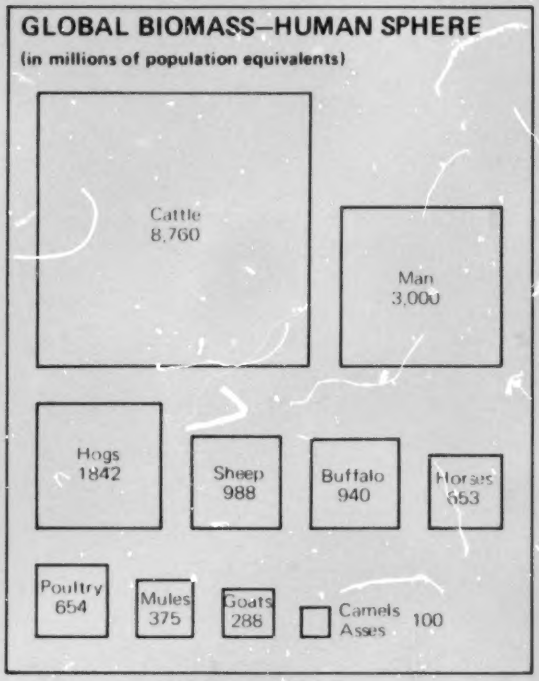


Figure 5.

From McHale, J. 1972,
World Facts & Trends, The Macmillan Co., N.Y.

Confronting Population Pressures

In Bucharest in 1974, the United Nations World Conference on Population convened to discuss ways to deal with future population as well as to identify particular areas of concern. Indicators of growing pressures on humans were found to be: evidence of lower weight at birth, shorter stature, impaired build-up of brain and nerve tissue, and an increased number of spontaneous abortions and miscarriages. The fact that there are simply too many people in many areas leads not only to famine but to frustration.

In less developed countries where modern medicines and public health services have reduced death rates and lowered infant mortality, only a small fraction of the people have access to family planning information. Throughout most of the developed countries, where family planning has been available, the family preference now equals two children.

The conditions for reducing population growth rates are still not clearly understood. • Is some critical level of economic and social development necessary to reduce growth rates? • Are problems of introducing successful population control programs, due to fear for old age security, concern over infant deaths, community status, religious belief, nothing else to do, lack of means of prevention, need for child labor? • Are the fixed roles for women responsible? • If some or all of these are problems, will integrated approaches to family planning be necessary for results, i.e. contraception, medical care for infants, old age security, and so forth?

And the query continues: • How do changes in male/female roles and relations affect population growth? • Biologically, is the sensitivity to protein and calorie deficiencies critical in rates of growth? • Can birth rates be controlled with protein increases? • Under what conditions will a nation accept long term sizable population reduction? • And, if they accept it, what happens to the labor supply?

Third World Fears

It is feared in many countries that efforts to control fertility represent a calculated attempt by the developed countries to check the future political influence of the third world and to protect Western access to raw materials. The majority of people in less developed countries are under governments who have official but inadequate population control policies. Popula-

tion policies however, are not a substitute for a long term development plan or program.

It is suggested that the development of population programs not only include family planning and population control, but also take into account the health of mothers and infants, women's rights, preservation of human rights, improved agricultural methods, methods of parasite control and opportunities for education, recreation and employment.

It is interesting to note, that many historical reductions in populations have happened in spite of government policies, church edicts, and so forth. Individual family decisions often play a large part. Apocalyptic events such as famine, pestilence, earthquakes and wars have also often intervened. In this last respect the gains are the losses. For example, in the two World Wars more basic natural resources were used up than in the entire previous history of people. In addition, most developed countries have spent large sums of money on armaments with relatively small amounts of funds applied to education and health care.

Escalating Energy Needs

Another input is the projected sixfold increase in global energy consumption expected by the year 2000. By that time the world population may have doubled and what will the critical problems be in reaching, for instance, a billion farm population which will be using technology for agricultural production while attempting to maintain energy efficiency?

Projections, however, represent an exercise in futility until some means of closing the widening gaps related to food, water and energy (fuel) distribution are determined, particularly as a growing, almost frantic, thrust into overcrowded cities is witnessed. Distributive justice or a more equitable distribution of wealth may be necessary. In an inventory of the globe, few persons seem to realize that we have not succeeded in providing adequately for the two billion persons added in the world since 1920.

Some serious problem areas include the known fact that birth control programs have not succeeded in some of the developed countries that encourage them. • Is it possible that the desire to live, as one force which drives the death rate down, is the same force that gives humans the desire to create life? • And that, in a complex turn of events at a time when opportunities for human well-being seem to be the highest, humans will be forced to ask questions about the quality of their own lives and the life they can offer their children? • And people may ponder further, is longer life the good life if it must be spent in pain? in fear? in hunger • And will these considerations lead to a lower birth rate because parents opt to limit the size of families?

Conrad Taeuber

John M. Richardson, Wouter Tims

Robert E. Huke

Gita Meier

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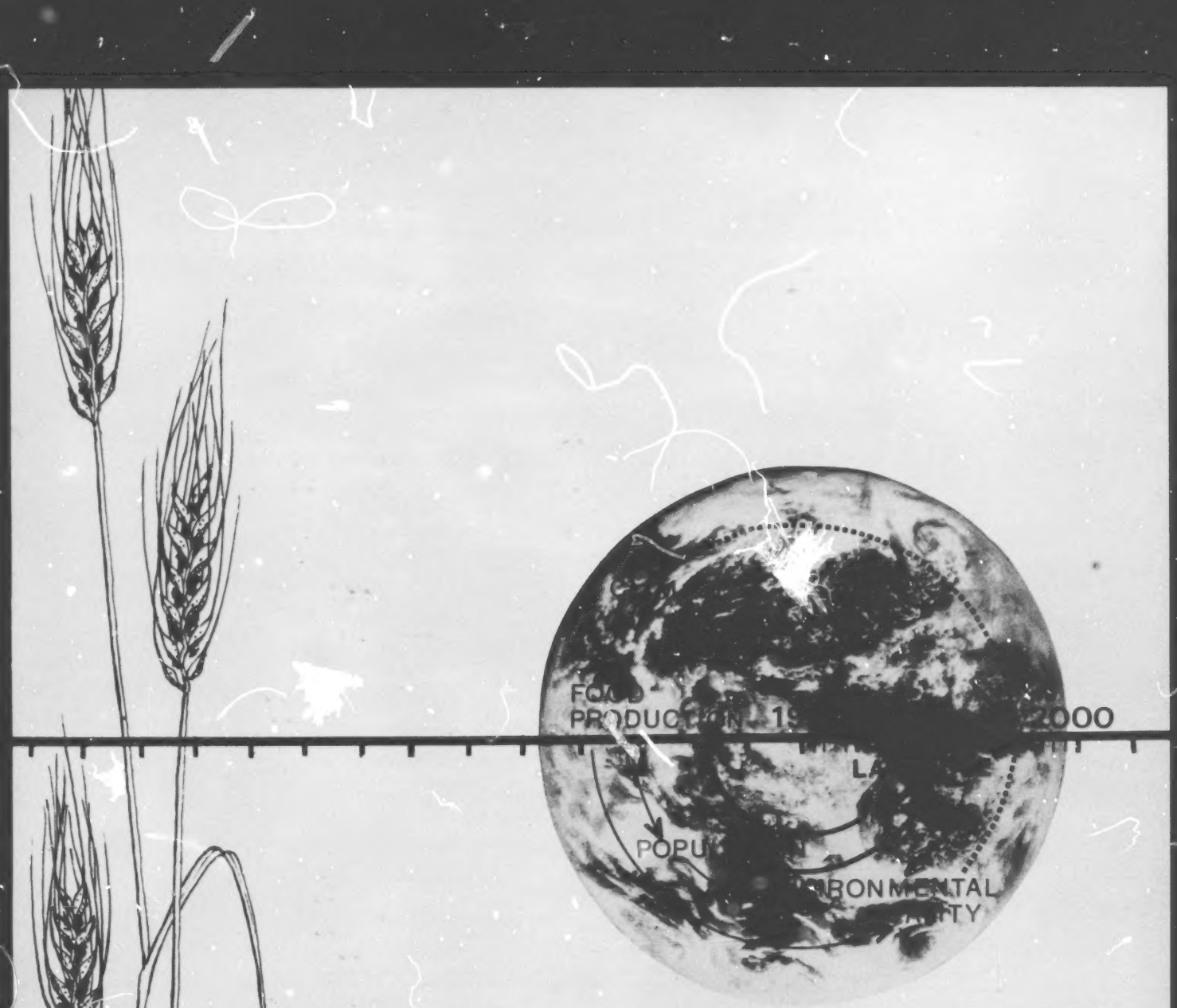


LAND USE

MAJOR CONVERSIONS

Food Production and Land Use

In people's quest for food and feed, more than one-half of the world's forest cover has vanished, large areas of grasslands have been converted to cropland and ground water reserves have been irreversibly tapped. Despite impressive postwar advances in agricultural technology which increased crop output per acre, 40 to 60 percent of the world production increases have emanated from expanded acreage. Today, in 1975, the cultivated acreage of the world involves 1.4 billion hectares comprising 11 percent of the land surface (Antarctica excluded) (See Figure 6).

It is not surprising to learn that this cultivated acreage is found on the world's most easily exploitable and best quality land. New lands are now both hard to find and more costly to develop. In addition, land resources of the world are not of equal quality, do not consistently produce food and fiber, and are not distributed according to world population.

Many of the best lands are in the developed countries. It is generally agreed that in the next 25 years there is still enough additional acreage which can be brought into production in North America to replace the projected loss of approximately 34 million hectares of its most productive land to urbanization, erosion, salinization, waterlogging, and other causes. But, any net increases in crop acreage beyond the replacement will require large investments per acre to handle poorer soils, procure special management skills and stimulate the clearance of land. In such instances, capital will have to be made available on a lead time basis. Guesstimates on new U.S. land that could be brought into cultivation are:

SE Coastal	**35**	**million**	**hectares**
Piedmont Area	**10**	**"**	**"**
Hill Country generally	**10**	**"**	**"**
Great Plains	**10**	**"**	**"**
Bits and Pieces	**20**	**"**	**"**
	85	**million**	**hectares**

By the year 2000, the land now in agriculture in the United States may yield twice the food it now produces as increased energetics efficiency of monocultures raises yields. But, it is relatively clear that producers will not readily adopt accelerated crop production without economic incentives. It is true then that the capacity of the

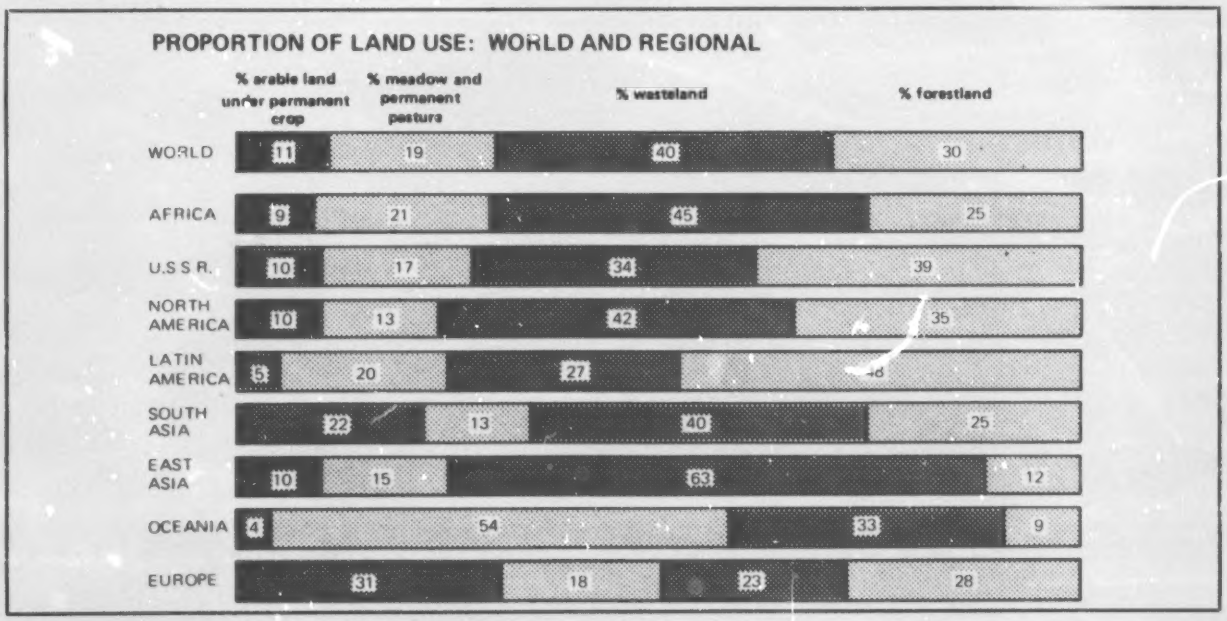


Figure 6.

From McHale, J. 1972, *World Facts and Trends*, The Macmillan Co., N.Y.

United States to keep pace with its growth and to increase food production by 50 percent is possible if there is more efficient use of land, if new land is put into cultivation, and if the U.S. is willing to pay the economic, environmental and political costs involved.

Net Land Losses

The situation in the rest of the world, however, is more bleak as a possible net loss in agricultural lands may ensue (See *Table B*) even though some new agricultural lands can be found near the current agricultural regions of Africa and Latin America. The huge sums of money involved in turning lands to production in the arid areas of the Middle East, North Africa and Asiatic U.S.S.R. will not change the net loss factor, although additional food production will be particularly essential in these areas. Some of this cost will undoubtedly be carried by income from Middle East countries involved in new energy development. Scientists say that in order to accommodate the future populations it is anticipated that one-half of the now remaining forests will have to yield to the plough, a projection which meshes poorly with plans to use forests to fill energy and wood product needs. Further, grasslands will diminish as crops take priority, and, game preserves and wild areas will drop to provide calories and protein through increased hunting and fishing. Both coastal regions and forests in humid tropical zones, while perhaps best suited for intensive agriculture, will demand heavy inputs of technology. The same input of technology will be necessary for the cultivation of ocean resources.

Other problems are raised as the variety of produce in developed countries is measured against restricted diet choices in many parts of the world. New decisions will have to be made on how much land will continue to be devoted to the more exotic foods and fiber items. The individual and collective needs and wishes of many cultures will be seriously involved in this issue.

Politics on Land and Sea

Addressing political issues, an international conference on the control of the sea beds was held in Caracas in 1974, to tackle problems of control and use of ocean resources.

There are also social factors affecting land use, for example, proprietary attitudes toward land, the fact that land for urban development is more of a market commodity than a resource, and, the often arbitrary nature of decisions on how parcels of lands shall be used and who shall use them.

Water needed for the development of land is yet another critical factor. The United States has sustained a fourfold increase in irrigated land since 1900 (15.8 million hectares)[2] and has ongoing planned irrigation projects designed to double available lands by the year 2000, a date when all known available water will have been appropriated. In this instance, it will be necessary to reckon with the fact that any of these major new irrigation works in the U.S. will have little effect on agricultural production before the end of the next two decades.

Ironically, destruction to land by floods is far greater than that by drought. Consequently, continuous flood control measures must be taken in addition to the above mentioned actions.

Unknowns

What we don't know is legion: • How finite is the present 1.4 billion hectare world agricultural land base and how far can it really be expanded? • What is the ability of the humid tropics and subtropics to provide food if given new soil and plant conditions and insect/pest controls? • What is the potential release of grain for specified reductions of livestock? • And again, can we develop continuous crop production in new places, for example West Africa? • How much food can come from an increase in backyard gardens, a chicken in every garage? • Can cropland conversion from industrial or forage crops to direct human food be significantly increased? • And finally, are there new synthetic foods which can help to close the food gap?

Many think that a redistribution of food to ease world poverty would have as its by-product the more productive use of land as it would afford developing countries an opportunity to "catch up," to have the strength to improve their own resources. The fact that the less developed countries are labor intensive is seen as an advantage if an intermediate technology were introduced along with direct food relief. Others feel that long standing social and political conditions may not allow the needed land reform in a number of the less developed countries.

Today, rising world food prices are continuing to increase pressures. While the amoral view accepts the fact that the economic inability to purchase food and fiber by a substantial portion of the world population will create less pressure on land resources, it is doubtful that such a flagrant stand in the present world could be taken without considerable social and political upheaval.

Major land use conversions will nonetheless almost always depend on a value judgment. It may be wise to remember that even where equitable distribution seems likely, humans have not, in the past, shown extreme care for the limitations of the earth. So far people have created five times more desert than cropland.

2—FAO Production Yearbook, 1972, Vol. 26.

TABLE B

Rough Estimates and Projections

USA 1975

Cultivated land	160 million hectares
Population	210 million
Land lost to urbanization (.25/capita)	14 million hectares
Land lost to erosion	20 million hectares
Potential land addition to arable base	34 million hectares

USA 2000

Cultivated land	160 million hectares
Population	265 million (.6 hectare/capita)

Rest of World

1975

Cultivated land	1.24 billion hectares
Population	3.8 billion (.33 hectare/capita)
Loss to urbanization (.12/capita)	.3 billion hectares
Loss to erosion	.3 billion hectares
Potential land addition to arable base (same % for U.S.)	.3 billion hectares

Rest of World

2000

Cultivated land	1.0 billion hectares
Population	6.1 billion (.16 ha./capita)

Ratio of U.S. to World in 1975 = 3:1

Ratio of U.S. to World in 2000 = 4:1

Land Use

In greater detail: 95 percent of the world food calories are of terrestrial origin while 10 percent of the protein comes from the sea.

The 1.4 billion hectares of farmed land in the world produce 3.9×10^{15} kilocalories of food. Per capita consumption in the world is 1×10^{6} kilocalories.

On an average basis it takes 1.4 acres of land per person to produce enough food to satisfy FAO food requirements (in calories). To provide the same calories from animal products takes 4.3 acres or about three times that amount.

In terms of what it takes in combined productive land, water area, and storage space to feed each person, land use varies greatly.

To gain some perspective on rice yields in terms of both quantity and type of production, figures from 1970 and 1972 emphasize the difference between yields from labor intensive agriculture vs. yields from energy intensive agriculture.

In 1974, the U.S. put back into grazing use some 45 million acres in semiarid sections in the middle of a period of severe weather problems (Cf. p. 10, Section I). There was also a threefold increase over the normal expansion of livestock. During the same time the less developed countries decreased their normal numbers of livestock by one-third.

De-Emphasizing Beef

The propensity for the consumption of animal protein by the developed countries keeps a disproportionate share of potential agricultural lands for feed grains and grazing. Many grazing lands do not lend themselves to croplands, particularly in semiarid areas. It is necessary, wherever possible, to maintain agricultural systems which encourage more direct food consumption, i.e. a shorter food chain. Some suggestions for lowering beef consumption include: a shift away from feedlot beef, an increase in cattle breeds adapted to natural range conditions, the possible limiting of range feed to feed pellets, and, a tax levy on high grades of beef.

Suggestions for utilizing the forest waste include such innovations as combining leaves, branches, and sawdust into a yeast food, however, a loss of good forest soil conditions and nutrients may result. Also, forests as a renewable resource make good use of solar radiation.

While the adverse impact of increased irrigation on climate is a gnawing question, suggestions for irrigating all land within 100 miles of the coastlines appear possible if the large amount

	Rice Harvested Area (in million hectares)	Total Production (in metric tons)	Yield/Hectare
Country **Ag. Type**			
China (labor intensive)	33,134	91,809	2.8
India (labor intensive)	37,443	57,188	1.5
Japan (energy intensive)	2,700	13,670	5.1
Australia (energy intensive)	42	260	6.1
Egypt (energy intensive)	476	2,277	4.8
Spain (energy intensive)	61	325	5.3

of additional energy needed for desalination of water can be obtained at reasonable cost.

For mineral lands, the expanding development of shale and coal can be viewed in many areas as a competing land use with crops. In these respects the trade-offs may be significant. Many scientists and economists feel that such development should require restoration measures, the adequate bonding of mining companies, and taxation on the removal of minerals. It has also been suggested that strip mining development be eliminated from areas with more than a 20 percent slope in order to avoid excessive erosion, and, from prime agricultural areas with less than 20% slope.

The treatment of land as a resource, not a commodity, is viewed as top priority in considering economic allocation factors. Improvements and reclamation of soil, development of more efficient water systems for irrigation, and more efficient use of land are generally thought to be highly possible.

Tax Incentives

The possible use of taxes to encourage greater diversity and better use of land is under continuous review. Tax incentives for farmers may stop the conversion of farmlands to non-agricultural uses. At the same time a surrender of development rights to keep the land in agricultural production may be possible.

None of these measures can hope to change the fact that there is still too little knowledge on how much and what must take place to enable people and nature to work together.

Land Use and Population

The introduction of costly high yield varieties has served to accentuate the differences between rich and poor farmers. It has also accelerated the farming of marginal land. The farmers flight to the cities has served to intensify the problem.

Human artifacts, i.e. homes, factories, dumps, roads, parking lots, and the like, comprise three percent of the land surface or .4 billion hectares. Every day governments, commissions and councils the world over approve plans for urbanization that encroach upon land that was previously cropped. Interestingly enough, recreation is one of the few land uses that is not considered a serious competitor with arable land.

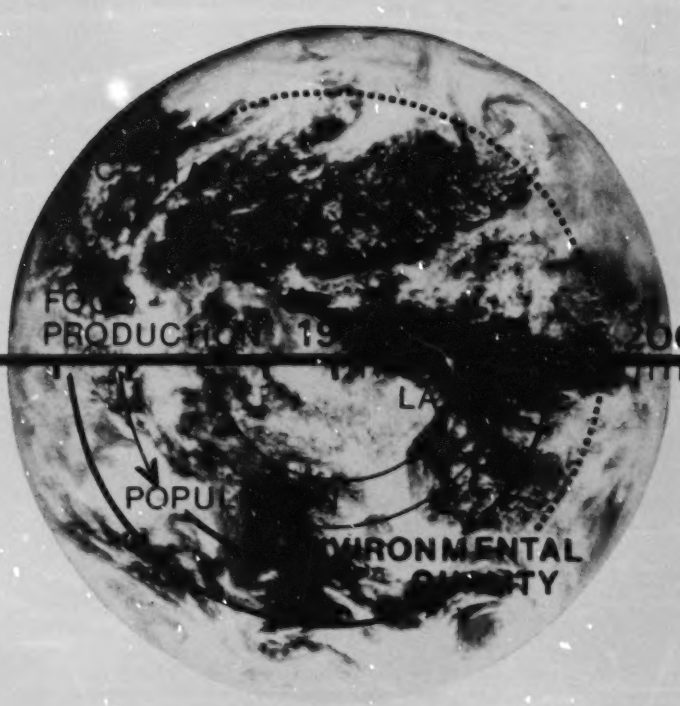
In the developed countries urban land use has been a filling-in process in which land speculators have played a key role. Now, a filling-in process in cities is required with priority given to policies which encourage greater density of settlement in areas presently urbanized.

Suggestions for heavily populated areas include an urban agriculture in which roof tops, urban green blocks and greenhouses become an integral part of the city. Encouraging the development of modified agricultural enclosures in suburban fringes is another suggestion.

Ideas for utilizing non-restorable mineral lands for high density development may be another alternative. In some areas of the world, e.g. Arizona copper mines, plans for such development are already underway.

Most of these suggestions would necessitate the modification of laws, and redeployment of population. How much potential increase in land use for food production can be gained through these measures is yet unknown.

Marion Clawson



ENVIRONMENTAL QUALITY

GLOBAL ARBITER

Food Production and Environmental Quality

The tradition of "stewardship" — never strong but persistent — dates back to the post-Platonic philosophers of the Roman Empire and especially to the teachings of Iamblichus in the 3rd century A.D. . . . Their starting point was Plato's Phaedrus *"It is everywhere the responsibility of the animate to look after the inanimate." (Passmore, 1974)*

The question here then is raised as to how people shall judge what there is to look after in the environment, how will they measure it, how will they manage it, how will they maintain it, and, if they can do only some of these things, how will the quality of their life be affected?

Such are the imponderables of addressing environmental quality; the term itself is a misleading one, as it implies a series of "preferred environments" rather than a solid base of knowledge on which actions might be taken.

Two Viewpoints

Some scientists arrange issues involving environmental quality into two groups; first, as a class of issues related to the maintenance of the total system and second, as a class of issues related to individual and group learned preferences and perspectives.

In the first group, the issues deal with environment in the Greek sense where ecology, as that science which investigates the nature and operation of ecosystems as entities, is interchangeable with economics, the science of production, distribution, and consumption of a system. Herein, the hard core facts about climate, water, soil, and air are the focus for constant observation, study and experiment. Any assessment, however, on the basis of long term standards to insure the quality of human life, begins to pose difficult questions involving posterity, and individual and group perspectives. What price posterity? It is in the second class of issues that people ask, what belongs to whom? and who shall maintain what? Here, for instance, "the quality of society's life is not as some people seem to assume, to produce a slide-rule of externally verified, desirable values and measure the society against them. It is to look and listen to ask what values are encouraged within society, what discouraged, what the society allows as norms without a risk for the individual of rejection or breakdown, how the society's patterns and values are changing."[3] It has been said that what is in dispute is not life but a "good" life, inferring that the quality of life moves far beyond the biological requirements for health and physical comfort.

In further exploring some of these issues, particularly as they relate to food production, several guidelines that belong to the biological system may be helpful in addressing environmental quality changes in the next 25 years. It is important where possible, to maintain diversity between and within ecosystems. Diversity guarantees a range of genetic resources and helps to insure the stability of systems. Attemps to increase net productivity usually subject systems to stress. As noted previously this was the lesson of the Green Revolution.

By the same token the increased rate of pollutants added by people (i.e. particulate matter, hydrocarbons, thermal effects, chemicals) begins, in the cycle that follows, to affect the air people breathe, the water they drink, and the soil in which their food is grown. To what extent these ecological costs have affected the less developed countries is yet unclear. Certainly, where increased food production is concerned the pressures of increased seed crops will make crops more vulnerable to water scarcity, insects and depletions from field to gullet.

Questions here also involve expected results from the anticipated doubling of energy requirements for the next 25 years, e.g. increased air pollution from the burning of fossil fuels; water and air pollution from energy intensive agriculture; and radiation hazards.

It would appear likely that physical standards will be resolved and set at regional levels. Further, a kind of social engineering will begin to shape human concepts of environmental quality as they are subject to new knowledge about the physical components, a redistribution of the world's resources and a very changed economic picture.

Four Approaches

How and what solutions will be introduced undoubtedly will be varied but the broad approaches will probably fall into four categories:

3—Hoggart, R. 1971. *Quality of Life*, Sixth Reith Lecture. 23 Dec., 1971 (Ref: p. 807 et seq.)

1. The laissez-faire approach whereby people live and die in their own way and where exploitation of natural resources is accomplished in accordance with national needs; each country having the right to determine its own environment. Some of this thinking results from the suspicion in newly developing countries that emphasis on environmental issues is a contrivance by the affluent world to suppress their development.

2. The idea that technology can solve anything is known as the technological fix. While technology can help, it is still only a tool, a distinctive human invention which demands knowledge and human direction.

3. More theoretically, the authoritarian approach is a product of a crisis atmosphere that colors much discussion of environmental problems. It is based on the belief that the present situation can only be solved by long term planning which will require an increasing amount of social regulation. This approach often increases fears many people have of further centralization of political power.

4. And finally, there is a democratic way, which although merits criticism in the abstract, takes for granted that people should be spared the hell of someone else's "heaven on earth." As short term as democratic planning seems to be, no other system has shown a greater capacity for avoiding ecological blunders. It is thought by some that this way offers more options for future generations.

The scenario for any one of these approaches might again be a world in which all excess resources for most societies are consumed in conflict with wars of redistribution and frustration, a world which would have little ability to cope with natural environmental disruption or social crisis unless hunger is recognized as the dominant force. In brief, individuals must overcome hunger before being concerned with aspects of the environment.

Environmental Quality

In 1970 the Annual Report of the U.S. Council on Environmental Quality showed that in spite of mammoth efforts to clean up the air and water over the last ten years, the ambient air quality was at about the same level it had been over the last three decades, and, that while water quality showed improvements in decreased biochemical oxygen demand (BOD), nutrients remained high. Given the added growth this levelling off in itself might be seen as an accomplishment. In addition, however, emissions of sulfur dioxide (SO_2) from steam power plants increased 250 percent between 1940 and 1970 because of a 200 percent increase in electrical power.

Looking ahead over the next 25 years at a few of those factors involved in air quality, it is believed that nuclear power will increase about tenfold in order to supply up to 20 percent of the world's electrical power needs.

Efficiency of fuel use is likely to drop from 50 percent to 40 to 45 percent due to the shift to electric power which will triple. Some efficiency losses will be made up by life style changes in developed countries, i.e. smaller and fewer vehicles, energy conservation measures due largely to a combination of education and direct controls.

No fusion reactors are expected before the year 2000, and only a small contribution, 2 to 5 percent, is expected from solar applications, although research and development will make great gains in these alternative energy sources. In terms of fuel, electric power projects will be operated principally from coal resources with more than one-half of the mined coal converted to liquid and gaseous fuels. The peak of world oil and gas production appears to be near the year 2000 with transportation needs and the remaining amounts increasingly reserved for agricultural uses.

Water Degradation

The growing infestation of weeds on the shores and banks of water bodies the world over poses problems in water use. Often weeds transpire more water than crops and the resulting depletion of oxygen reduces water for irrigation, decimates fishing, increases water borne diseases (e.g. in Africa) and upsets the cleansing of oxygen in the larger cycle. Biocontrols include plant eating snails, fish, seacows and waterfowl which could become essential links.

Mounting pollution via sewage, industrial wastes, and runoff resulting from population and urban congestion is causing a eutrophication of lakes in many places.

In irrigated agriculture the excessive use of nitrogen fertilizer is surpassing the phosphorous and potassium elements thus upsetting the needed balance between the three elements. The lack of any one of these weakens the water economy of plants and affects the efficiency of nitrogen utilization.

And, finally, the mining of "invisible" groundwater collected over milleniums continue to deplete supplies.

The Unknowns

Considering again the need to manage or maintain environmental quality people are faced with a bevy of unknowns: • What for instance are

the limits of tolerance for air pollution, water pollution, the degrees of simplification of the ecosystem that we can still manage? • And, how long can we evolve domestic plants faster than evolutionary genetic changes where plant diseases and pests are concerned?

• What are the long range effects of lower-level radiation? • How can we estimate possibilities for managing food production when we don't know enough about rains or about the ground water impacts of introduced chemicals, especially for long period recharge? • What are the practical benefits of a chemical agriculture? The gaps in information further include inadequate knowledge of net economies and trade offs in land use, in energy development, in disease control vs. the effects of insecticides and pesticides.

In looking for the least disruptive way to lower per capita requirements of resources and fuel in developed countries and for handling problems unique to less developed regions, interdisciplinary scientists capable of undertaking environmental research are needed.

Environmental Quality and Population

The maintenance of the total system does not refer to just the physical properties, climate, water, soil, air, and the survival of some animal and plant populations. Problems of the quality of the human environment are only partly biological. The issue of individual and group definitions and perceptions play a strong, although not clearly defined, role. It is possible that the many aspects of humanism which cannot be conveniently pigeonholed or computerized represent the strongest determinants of environmental quality. It may be that survival of Western civilization is at stake, not the survival of the species.

Indira Gandhi said at the 1972 U.N. Conference on Human Environment in Stockholm, "How can we speak to those who live in villages and in slums about keeping the oceans, the rivers, and the air clean when their own lives are contaminated at the source?". Drawing interrelationships across such distances is all but impossible and the rights of the environment almost appear to be independent of the rights of humans.

Rapid population growth in many parts of the world is clearly playing a major role in affecting the quality of environment and brings up issues which suggest that, equal opportunities for women, a respect for the rights of minority groups including homosexuals, and abortion available on demand, are appropriate steps in directing the world towards a greater degree of stability. The realization that thought and behavior depends on a sense of responsibility and discipline as well as on the acquisition of rights and knowledge may be important, as there are many innovations that could be introduced which require clear-headed planning. For instance, what social and population distribution changes are needed to re-cycle wastes to increase food production?

Hard on the heels of the world conferences on environment, population and food, is yet another one to be held in Canada in 1976 on Habitat. The world attempt to cope with its problems continues.

Environmental Quality and Land Use

Cultivatable soil is always subject to erosion, floods, saturation, and a breakdown of organic constituents. Today, one-seventh of the world's present acreage is affected by the above conditions. A soil survey in India showed that one-quarter of the tilled land will lose its topsoil before the end of the century.

Specifically, increased food production practices in many areas decreases the quality of soils by increasing salinization, nitrate in ground water, laterization, erosion of marginal lands, and overgrazing of grasslands, e.g., salinization makes salt removal necessary, erosion leaves less organic nutrients, and less plant productivity means fewer animals. The balance of soils is a key factor in transporting volumes of water over land. Domestic and industrial uses of water are climbing. Water consumption in urban areas involves for instance an average daily use of 150 to 200 gallons per capita in the U.S. This is 7 to 8 times the amount available to those who live on the other side of the "consumptive gap" and have to manage with 20 to 25 gallons per capita per day.

• Can we convert land to feed increasing populations with ecologically sound people/land interaction? • What exactly will the change in food consumption and preferences affect? • If pollution standards are strongly involved, will economic hardships be subsidized? • Will the utilization and conversion of animal and plant waste for food and fertilizer make a significant difference? • What competition will acreage for possible solar power generation complexes offer croplands?

U.S. coal conversion in the next 25 years will double its land requirements. Land losses resulting from new strip mining requirements will amount to 35,000 square miles (unless coal conversion efficiencies improve). Adoption of a "scientific area" plan for coal production may restrict new land requirements to 25,000 square miles.

Concluding Remarks

There are some areas which must be preserved at all costs. Watertronts, bogs, marshes, and other wet lands and estuaries are extremely important lands for the movement of tides and water drainage which in turn protect water quality.

And lastly, completing the cycle of interrelationships we are led back to the effects of particulate matter on climate as we recognize how little we know about pollution. For instance, what is the rate of pollution being added, and, what is its ultimate disposal in the biosphere?

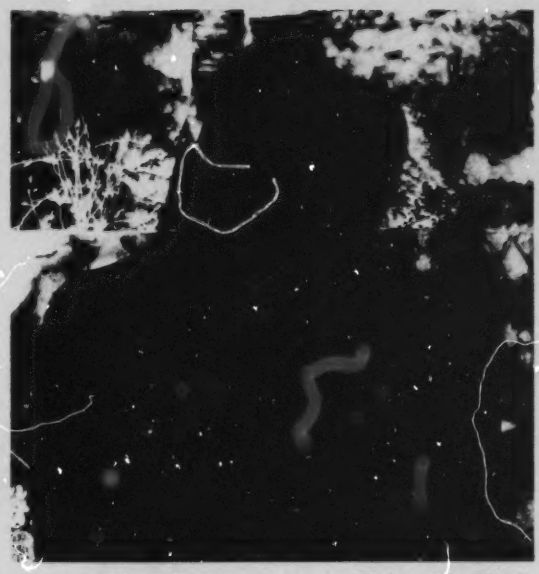
We are suffering from over-rapid changes and readjustments to demanding pressures. Are we overreacting or do people foresee something out of their relatively new scientific knowledge? In reflecting on the disasters of the natural environment, earthquakes etc., that have occurred for milleniums of history, there may be some natural guidelines to follow in the reconstruction of nature.

"It were good if men in their innovations would follow the examples of time itself, which innovateth greatly but quietly and by degrees scarce to be perceived."[4]

Today, this might be interpreted to mean that a steady and deliberate move to understand and work on the problems will bring about a less chaotic state for both the quality of human life and the environment.

4—Bacon, F. 1625 (?) Essay on "Innovations."

James B. Cragg



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Some Study and Research Needs

The following list, compiled from the workshop notes, attempts to identify some information gaps in a number of problem areas. Due to the broad scope of the workshop, there was insufficient time for the participants to prioritize the list or make more specific research recommendations which might better reflect the interrelationship theme of the workshop.

- Use of long term historical meteorological data to produce statistically derived climatological analyses.
- Expanded climate studies utilizing ERTS monitoring program.
- Net energy studies.
- Inventory of the world agricultural base.
- Role of water in agriculture.
- More studies on weed/crop yield and insect/yield interrelationships.
- Climate/crop yield relationships in rice production.
- Experimentation and analysis of multiple cropping and crop succession.

- Study time estimates of crop yields.

- Study the beneficial role (if any?) of various animals in food production. Is green manure better than brown manure?

- Study animal production as part of major waste-recycling systems.

- Recycling of waste back into food needs and fertilizer on a major scale.

- Study technological problems involved in using enriched pellets on grazing areas and marginal lands; feed concentrates.

- Fish farming studies.

- Genetic improvements in crops and animals, i.e. multiple birth systems.

- Inorganic fertilizer development in certain regions, e.g. West Africa.

- Non-conventional agricultural techniques as a supplement and/or replacement for marginal land areas e.g. controlled agriculture.

- "Ecologically sound" tropical agricultural techniques involving soil-plant relationships and insect pest control.

- Rainfed rice in international areas should be the focus of rice research to produce and develop rice varieties able to withstand drought and produce reasonable yield under difficult conditions.

- Study the optimal configuration of a world food reserve system.

- Protein studies related to population growth.

- Analyze food issue as to infrastructure of grain elevators, storage facilities, food processing plants, roads, etc.

- Food utilization: food preparation methods that are "low energy," e.g. preventing overcooking.

- Global land resources studies to increase the utility of marginal land and to correlate locational demand for food and fiber with a comparable locational supply.

- Inventory storage of food on a regional basis.

- Study ways to impact policy makers on production capabilities, distribution limits, nutrition and health considerations.

- Study change in food consumption (preference and amount) and its effects on environmental quality.

- Study of world distribution of food; develop a distribution plan.

- Effective inputs of manpower and resources into agricultural production.

- More effective packaging of aid for food, family planning, health, and education.

- Use of low cost delivery systems.

- Potential world income study.

- Study market problems in relation to crops.

- Widespread local, intra-county and regional projections of population and probability of food production.

- Improve information dissemination in developing countries i.e., on production methods, distribution, utilization in relation to local and public administration system.

- In recognition of problems, study the need for an international agreement and decisions on resource transfer; i.e. how much money from developed countries to less developed countries, how to distribute food among third and fourth world countries.

- Creation of a new kind of village economy at different level of sophistication and economy means e.g. "Blueprint for Survival."

- Study of the cultural, economic, social and political variables which traditionally generate misallocation of resources from a human satisfaction perspective.

- Research "long term" oral or injection contraceptives.

- Study ways to increase socio-cultural acceptability of family planning, family size and delimitation locally.

- Study the social effects of the global spread of fission power.

- Technology assessment that works for social as well as technical issues.

- Formulate data in terms of key metals, i.e. iron, copper, aluminum, zinc, nickel, and lead. Investment for this should be doubled to 30 billion dollars.

- Develop more cooperative institutional training programs.

- Train more population scientists and technicians; better distribution of expertise.

Participants Response to the Workshop

It is said that "a scientist must be able to distinguish between his views, first, as an expert, secondly as an informed individual, and thirdly as simply another member of the general public." Where the Output Report is the outgrowth of the scientists participating as "experts," the following statements were made by the "experts" as they responded to the interdisciplinary workshop on the level of informed individuals. The levels of encouragement herein expressed are perhaps born out of an inclination to put the most favorable construction upon the actions and events predicted for the next 25 years in order to insure support for humankind, and to provoke optimum human performance, in the face of overwhelming pressures to recognize findings that suggest few alternatives to a conflict ridden world. In no way is such encouragement blind nor unknowing, rather, it is possible that it comes quite legitimately from a 20th century heritage in which Western people have come to believe, with the help of science, that individuals and groups can have a hand in choosing something of the form in which life will be lived. It is possible that people in the oncoming years will bend themselves to the wheel to prove it.

(EWI)

Most Encouraging Thing About the Workshop

"Green revolution yields, at least in some areas, have been more promising than I had expected. This is tempered by the 1974 results."

"Creative thinking about the designed use of resources, considering all sorts of system interactions, may allow tremendous improvements in the quality of total human existence."

"The fact that consideration of climate, as an important component of the food-population-environmental quality problem, was seriously included in the agenda for this conference . . . and that several of the participants were willing to include a realistic perception of climatic impacts in their discussion."

"A feeling that most persons at this workshop are more encouraging about the ability of the world to feed itself in the next 25 years than is the popular literature in general, i.e. Famine 1975 and Meadows model do not hold the belief here as they appear to in the press. There is some hope — for 25 years at least."

"The swing from pessimism to subdued optimism that the world's hungry can be fed — that substantial efforts can be made to meet that challenge within the next 25 years."

"The degree of detailed work in progress to solve the 'problems' is greater than I had thought."

"Experts over a wide range of areas of interest speaking a common language and expressing converging concerns and priorities."

"Science (organized thought) can measure, trace causations, predict (in some cases) numerous aspects of climate, land, environment, food supply, etc. We do have great parts of our total life within our control, if we have the energy and will to use our capabilities."

"That the group did not come to the conclusion that the world food situation during the next quarter century is hopeless. The problems to be solved in some cases are monumental but the ways of solving them are in general available, given the political decision, technical assistance and will to work toward their solution. This 'cautious optimism' makes it possible to sidestep the moral issue of the 'life-boat' theorem."

"With regard to world situation, nothing, except possibly a hope that there is concern and awareness of global problems which did not exist two years ago. With regard to research — I was encouraged by information about availability of climatological data of which I was not aware."

"The recognition of the broad interrelationships and the careful approach to investigation. The objectivity which avoided a 'crises' approach at the same time avoided glossing over the problems."

"Encouraged by the information that is available on climate and crop productivity that enables us to put into perspective recent comments and questions that have been raised about effect of climate on world food productivity"

Most Discouraging Thing About the Workshop:

"Famine, the observation that many cities are limited by the availability of reliable supplies of water. The flow to the urban areas of the world continues and even stringent measures to prevent it in some regions of the world have been only partly effective. In this case the time to disaster is so much shorter than for food that possible world response to such a crises is likely to be totally ineffective."

"Our abysmal ignorance of changes occurring throughout the world environment and the effects of such changes on humans, their health, happiness, and general welfare."

"In some instances, we are still proceeding to perceive the problem of food/population as not really involving climate fluctuations. Specifically — the modelling of food/population/economic interactions, in too many instances has not yet included climatic variability. The statement that all we have to do to greatly increase food production is to increase the prices guaranteed to farmers does not allow for the impact of unfavorable weather (as in 1974, when prices were much higher than in 1972/73) yet we actually saw a substantial drop in production in many areas of the world."

"There appears to be no way to get the population numbers to a steady state without at least an increase of 2x or 3x the number of people. This reaffirms my belief held prior to the workshop."

"That throughout our discussions particularly on policy we have thought too much within terms of the current 'market mechanisms' and not enough attention has been given to alternative policy approaches and particularly to the qualitative aspects of life. We have been more concerned at keeping people alive, rather than how they will live."

"There were no major decision makers in terms of political policy here to hear all the thought processes that went into the meeting. They will judge only the summary!"

"The considerations remained at the management level (2 to 10 year horizon for action) while the biggest and most challenging effort is in perspective planning (as indicated by the presumed horizon of 2000 A.D.) which has a ½ to 1.0 generation horizon. We rarely get to the perspectives for planning anywhere in the world until later in the discussion, but I did get a few hints of helps to come from some of the participants."

"Too much emphasis on the role of the U.S. in the world system, which tends to distract from the capabilities in other parts of the world to contribute to meeting challenges. This then leads to lack of focus on the need to recognize the facts of growing interdependence in order to get better international cooperation. The latter involves a substantial degree of responsibilities to be assumed by others and the issue is, how to balance those worldwide and what policy instruments will play."

"Demographic momentum, or inability quickly to adjust reproductive habit of our species to natural and social environment in which we live today."

"The lists of unknowns presented in almost all categories are rather forbidding — both in terms of numbers and degree of difficulty in achieving more knowledge. In some cases the political decisions necessary for implementation may be difficult to achieve."

"Most of the group provided information which would tend to make predictions from our models more pessimistic — and they are already pessimistic enough. No one provided information which would contribute to more optimistic predictions. No encouragement except in the area of climate with regard to availability, reliability and usefulness of data."

"The absence of any scentist from the developing world who would have challenged many of our conclusions as culturally limited — to take only one example: did we not rationalize the continued production of red meat because we happen to like its taste?"

"I continue to be bothered by the fact that no conference in the world, in spite of all the information it develops about food production potential, can deal with the hard social, political decisions, that must be made if food that can be produced is to be made available to the person who needs it."

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The Charles F. Kettering Foundation has five programs involved in: 1) the dependence of food production on nitrogen fixation and climate; 2) the improvement of schooling; 3) unofficial international communication on critical issues, and leadership education and citizen involvement in international relations; 4) researching coordinated urban policy and citizen involvement; and 5) exploring the transformation of advanced societies and related communication techniques. One of the missions of the first program has evolved since December 1973 from an overview of the world food issue to its present focus on the feedback relationship between food production and climate. The evolution of the Food Production/Climate Mission was substantially aided by the Query into the Quarter Century Workshop. The other missions involved with food production conduct basic scientific research on nitrogen fixation at the Charles F. Kettering Research Laboratory.

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